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ABSTRACT

Although the Congress of the United States has enacted legislation calling for a conversion to the metric system by October 1992, recent government reports suggest that the country may not be prepared to meet that deadline. In an effort to develop a learning module for instructing community college students in the application of the metric system, five needs assessment and evaluation surveys were conducted. The first survey was administered to a target group of six community college science department instructors to determine the length of time it should take students to complete such a learning module. This information was combined with findings from a survey assessing instructional content requirements to develop a first draft of the Metric System module materials. Development of the learning module included creation of pre- and post-tests to assess student learning, a module videotape, an instructional computer program, a student workbook, and an instructor manual. Copies of the first drafts of the student workbooks and teacher's manual were given to the instructors in the initial target group who were asked to recommend changes. In addition, three follow-up surveys were created for faculty to evaluate the module videotape, the tutorial computer program, and the complete learning module. All faculty who completed the follow-up surveys gave approval to the materials which had been developed. A literature review, plans for implementing the module among all biology students at a targeted community college, the videotape script, survey instruments, summaries of instructors' comments and recommendations, and references are included. (GFW)

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A COLLEGE LEVEL PROGRAM FOR INSTRUCTING THE METRIC SYSTEM

by

Marjorie A. Thrall

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A Practicum Report

submitted to the Faculty of the Center for the Advancement of Education, Nova University, in partial fulfillment of the requirements for the degree of Master of Science.

The abstract of this report may be placed in a National Database System for reference.

December/1990

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Abstract

Designing a College-Level Program for Instructing The Metric System.
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The Center for the Advancement of Education.
Descriptors: Metric System/ Mathematics Education/ Mathematics Curriculum/ Mathematics Instruction/ Mathematical Applications/ Community Colleges/ Measurement/ Federal Legislation/

A majority of community college students enter science and math courses without the necessary background information in the area of metrics. Five needs assessments were used to identify which topics needed to be instructed to the college-level student in the area of metrics. One of the needs assessments questioned the target group of instructors for the average length of time the student should take to successfully complete a Metric System module. The instructors' input was used to create the first draft of the Metric System module. The implementation of the practicum was to create a Metric System module which included designing a pre-test, making a videotape, locating an applicable computer disk, writing a student's workbook, authoring two post-tests, and writing an instructor's manual. As each component was created each instructor was given a copy to evaluate and make comments. The results indicated that 100 percent of the target group of community college instructors approved of the Metric System module. Appendices include the script for the videotape, a copy of the workbook, and a copy of the instructor's manual.

Authorship Statement

I hereby testify this paper and the work it reports are entirely my own. When it has been necessary to draw from the work of others, published or unpublished, I have acknowledged such work in accordance with accepted scholarly and editorial practice. I give this testimony freely, out of respect for the scholarship of other professionals in the field and in the hope that my own work, presented here, will earn similar respect.

Signed: Marjorie A. Thrall
Student's name

III/IV

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CHAPTER I

Purpose

Adoption of a new measurement method can be likened to a puzzle. In the United States all pieces of the metric puzzle need to be in place before the final conversion to metric conversion can occur. Even though the beginning stage of completing the metric puzzle is through education of young adults and eventual leaders in the fundamentals and benefits of Metric System use, the entire country must work towards metrication. All four corners of the puzzle, i.e., the elementary level, the middle school level, the senior high school level and the college level must educate cooperatively so as to convince the mature middle segment that the puzzle is not complete until all have accepted the change (Figure 1:2). Elementary level students should have the entire topic of measurement taught only in the context of the Metric System. Although middle-school-aged students have been introduced to the English System of measurement, neglected basics of the Metric System must also be taught. High school students can learn

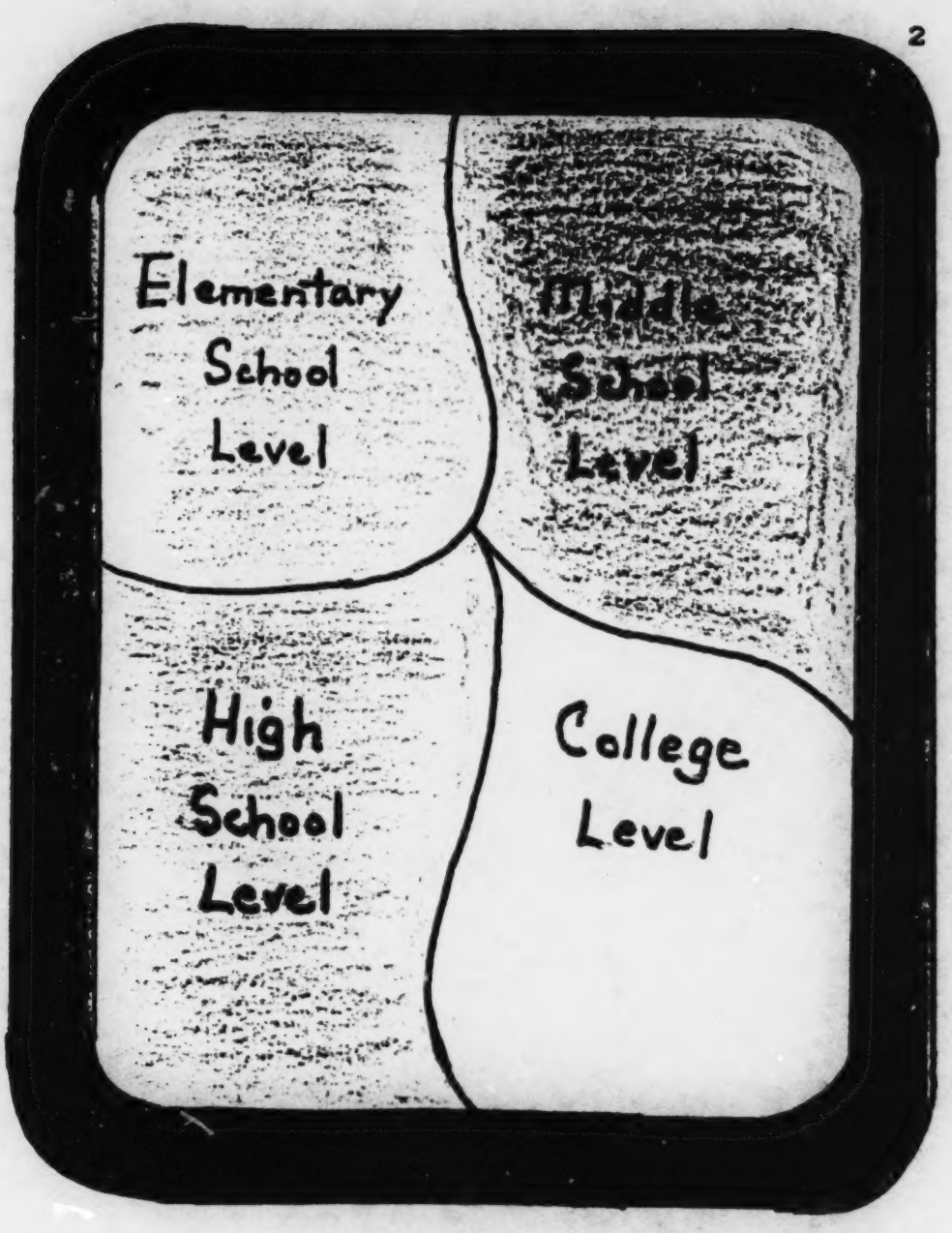

Figure 1

The Metric Puzzle

to use the Metric System in mathematics, science, physical education and shop classes. College-level students should be instructed in this method of measurement as a prerequisite to science or computer electronics courses. Pieces in the center of this puzzle will fit together when the adult population becomes sufficiently convinced of the value of using the Metric System as a positive economic factor. Acceptance of this system has not been achieved to date. This writer was concerned with one segment in completion of the puzzle: instruction of metric measurement to college-level students.

This writer is presently a Math Lab Supervisor at a community college. The job responsibilities of a Math Lab Supervisor include tutoring students from a basic arithmetic level through calculus, managing a staff of student tutors and one Math Lab Assistant, coordinating the Math College Prep program, instructing the Math College Level Academic Skills Test (CLAST) Review course and the Math Study Habits Course.

The writer distributed a metric needs assessment to each member of the Science Department of the targeted community college's south campus. The

Science Department consisted of the following instructors: one who taught biology and botany, one who instructed biology, zoology, and anatomy and physiology, two who taught chemistry, one who taught earth science and Astronomy, and one who taught biology and macrobiology (Appendix A:52).

All six of the science instructors indicated that there was a need for a prepared curriculum package for instructing the Metric System. The respondents also replied that the time presently spent teaching the Metric System ranged from "less than one hour" to "four to six hours". The science instructors stated that the following topics must be covered in a Metric System module in order to eliminate a deficiency between what the students presently know about the Metric System and what the students should comprehend about the Metric System: History of the Metric System; Present Adoption Status of the Metric System in the United States; Metric System to English System Conversion; English System to Metric System Conversion; Metric Length Computation; Metric Area Computation; Metric Volume of a Solid Computation; Metric Volume of a Liquid Computation; and Metric Mass Computation.

All six respondents displayed an interest in having the students participate in a program which would include a Metric System Inventory Test at the beginning of each science course. Students scoring below 80 percent on this Metric System Inventory Test would then be required to complete a Metric System module in the Math Lab.

The Metric System became a means of legal measure in the United States by an Act of Congress on July 28, 1866, and is currently found as law under United States Code, Title 15, Chapter 6, section 204-205. The United States was one of only seventeen countries present at the signing of the Treaty of the Meter in 1875, which initiated the International Bureau of Weights and Measures and resulted in the then new distribution of platinum-iridium standards for the meter and the kilogram. As of 1893 Mendenhall, superintendent of the United States Coast and Geodetic Survey and the Office of Weights and Measures, transferred the American primary standards of length and mass to the meter and the gram.

Two laws have been enacted within the last 15 years to promote use of metric measure. The Education Amendments of 1974 were passed to encourage the study

of the Metric System in the classroom. The Metric Conversion Act of 1975 (Public Law 94-168) was passed with the intent of having the official policy of the United States promote more planned use of the Metric System. When the Metric Conversion Act became law, a seventeen member board comprised of representatives from industry, small business, the labor force and other sectors of the economy was formed to encourage and facilitate voluntary conversion to the Metric System and to coordinate the education of different sectors of the American community. No timetable for conversion was established even though United States leaders were convinced that time was imminent for America to join the rest of the developed world in the more popular measurement system (Nelson, 1983).

The United States and Burma are the only remaining countries using the English System of measurement, i.e., inches, feet, miles, pounds, gallons, et cetera. Educators have promised to help the country convert by teaching the Metric System to American students. Schools introduced the Metric System, but the topic was not and is not emphasized.

"There's tremendous social resistance to converting to the Metric System," stated Weis (1984: 49). "Until we start teaching in metric, it's going

to be many years before we convert" noted Dishman (1984:50). Norton (1984:50), an adjunct instructor at the United States International University's School of Education, said there is "no real effort to teach the Metric System. It's introduced, but it's not emphasized and it's certainly not used."

A new government report voiced concern that the United states may not meet the October 1, 1992 deadline for the country to adopt the Metric System. Even though the United States Congress mandated the conversion to the Metric System, most of the federal agencies "... have not advanced beyond the early stages of planning," the General Accounting Office reported (Cited by Chen, 1990:A36).

One of the greatest disappointments mentioned in the report was the lack of action contributing to the conversion by the Department of Commerce. The officials at the National Aeronautic and Space Administration, the Pentagon, and the General Services Administration place the blame on the Department of Commerce's lack of commitment as a major cause for the weakening of the effort towards Metrication. The report's conclusion was that the slow pace of Metrication "... may delay or prevent a timely and

comprehensive conversion to the Metric System," (Quoted by Chen 1990:A36).

Since the federal government is the purchaser of nearly five percent of all goods and services produced in the United States, the government hopes to be a catalyst in the Metrication process. "I don't deny that the General Accounting Office is right that we didn't apply enough resources," Underwood, United States Commerce's Director of Metric Programs, agreed (Quoted by Chen 1990:A36). Because the House of Representatives subcommittee on Science Research and Technology became alarmed at the General Accounting Office's conclusions, a hearing was arranged for April 24, 1990.

> The conversion is a great challenge but it is absolutely vital that we meet this challenge if our businesses are to compete effectively in the global market place. (Chen, 1990:A36)

In the report, the General Accounting Office pinpointed only one of the 37 main federal agencies to develop a plan identifying which sections under that agency's scope should be reviewed for conversion. The agency had not written a specific timetable for Metric conversion. The General Accounting Office's report "... calls into question the federal agencies' commitment to the transition..." (Chen, 1990:A36) plus

stating that "... nine of 10 important interagency subcommittees have not convened." (Chen, 1990:A36). One statement in the report was that two-thirds of the 37 agencies surveyed by the General Accounting Office surveyed have not decided which officials will be responsible for the mandated Metric Conversion.

Needs assessments given to the math and science instructors at the targeted institution revealed general agreement that Metric System emphasis is of vital importance in the preparation of college students for entry into a modern science course or a computer electronics course (Appendices B and C:55-56 and 58-59). If metric measure is taught to college students before major specialization courses are introduced, the metric concept will be immediately reinforced in subsequent science courses. This metric instruction will make college graduates much more productive members in the ever growing and competitive international business, scientific and educational worlds.

RESPONSES TO THE METRIC NEEDS ASSESSMENT GIVEN TO MATH, SCIENCE AND TECHNOLOGY INSTRUCTORS

DATE OF NEEDS ASSESSMENT: SEPTEMBER 1989

Teacher 1, a physics instructor, commented "...any instruction which teaches them to convert from any one unit to another would be helpful to the students entering into physics, where they use that skill quite a lot."

Teacher 2 commented, "As I recall the goal was to have metric measurements proficiency a part of our general education in the 1950's! We certainly have not come very far!"

Teacher 3, a science instructor, stated "Metric System and scientific notation go hand-in-hand. The students, presently, have poor proficiency in both. This situation needs serious corrective action."

Teacher 4, a computer science instructor, conveyed the following, "American students should have a strong grounding in the measurement system used by the majority of the world's people."

Teacher 5, a math instructor, commented, "I think textbooks should start using metric more but then if the community does not want to use metric it will be a slow process."

Teacher 6, another math instructor, stated, "I think it should be taught in one of the lowest level math classes. If a student doesn't take that particular course, then it is the student's responsibility to learn it on his own. By the way, it is an objective on the State Student Assessment Test (SSAT) which all Florida high school students must pass to graduate." (This topic was discussed with McClendon, the Sarasota County Math Supervisor. Only 42 percent of the state's metric objectives are tested on the third, fifth, eighth and eleventh grade Florida State Assessment Tests as of September 26, 1989.)

Teacher 7 said, " The United States failed in its agreement with Canada over 10 years ago. The federal, state and local governments must get involved and set a deadline for conversion, make and implement plans for doing so."

Teacher 8, a computer science instructor, stated " As a computer science instructor, I frequently assign projects which use the Metric System. Most students have little understanding of the need for the Metric System. I would like to see this remedied but I doubt it will be until our society as a whole commits to it."

Teacher 9, an astronomy instructor, critiqued the present form of metric instruction, "College class time is not sufficient for in-depth review or training; the Metric System must be a part of every student's fundamental math development."

A third type of metric needs assessment was also given to Rand, Head of Student Services of the South Campus of the targeted community college, and Chapura, Counselor at a neighboring high school (Appendix D:61). The two concurred that the Multiple Assessment and Program Services Examination (MAPS), given at the targeted community college as well as at many community colleges to determine a student's math placement, does not test for metric comprehension. The American College Test (ACT) and the Scholastic Aptitude Test (SAT) both include questions on the Metric System. Rand commented that the SAT and the MAPS are both written by the College Board and section TSEE is exactly the same. These exams are quite often used as placement and acceptance criteria for a college or university. During the 1988-89 school year, only sixty out of sixteen hundred South Campus students took a math course that helped prepare students to utilize the Metric System in possible subsequent science, computer electronics and nursing

courses.

A fourth needs assessment was directed to Department Heads of Math and Science at five community colleges in this writer's general area (Appendix E:64-65). Edwards, Mathematics Department Head, stated that only approximately two percent of the student population takes course material that includes instruction on the Metric System before entering a science or computer electronics course.

Wilson, Science Department Head, did not foresee a need to instruct the Metric System before the student entered one of the department's science courses. Jordan, Mathematics, Science and Technology Division chair, commented that approximately 15 percent of the students are instructed on the Metric System in a mathematics course. Jordan did see a need to teach the Metric System before a student enters a science or computer electronics course, but at the present time did not foresee a way to provide it. Newton, Division chair of the Math, Science and Technology Division, felt that less than 10 percent of the college's student population receive metric instruction before entering a science or computer electronics course. White, Mathematics Department Head, approximated that 50 percent of the student

population has been instructed in the Metric System in at least one math course. Campbell, South Campus Division Chair, foresaw the need for metric instruction within the science and computer electronics courses.

Needs assessment results obtained during the week of September 18, 1989 from the Math, Science and Technology Instructors of the targeted community college indicated only 45.4 percent of the instructors teach the Metric System in class, yet 77.2 percent of these same instructors indicated that the Metric System needs to be instructed before the college student enters a science or computer electronics course. The Computer Electronics Lab Director of the targeted community college commented, "It is not difficult to update the students with the K-G-S System. We handle it on the fly." Due to the Electronic Lab Director's views on instructing the Metric System, the author's Metric System module will be initially implemented only in the science courses.

To summarize, a majority of community college students enter science and math courses without necessary background information in the area of metrics. Instructors in the affected areas agreed a method of supplying this information was necessary.

Instructor A of the targeted group of instructors received a Bachelor Of Arts Degree in Mathematics, a Bachelor of Science Degree in Computer Science, and a Master of Science Degree in Mathematics. Between 1977 and 1979, instructor A taught Mathematics and Computer Science. Since 1979 this instructor has also been a full professor of Mathematics at the targeted community college. From 1983 until present this person has been the chairperson for the Division of Math, Science and Technology at the community college. Instructor B of the targeted group of instructors has a Bachelor of Arts Degree in Biology, a Master Of Science in Avian Ecology, and a Doctoral Degree in Medicine and Surgery. The instructor has taught two years of Biology at a day school, seven years of Biology at the post-secondary level, two years of Physics and Physiology at a private school and three years of public school Biology. The instructor currently teaches Biology at the targeted community college. Instructor C of the targeted group of instructors has obtained a Bachelor of Science Degree in Biology and a Master of Science Degree in Plant Physiology. Before becoming an instructor of Biology at the targeted community college, the instructor was a research assistant for six years. Instructor D of

the targeted group of instructors has a Bachelor of Science Degree in Chemistry and Biology, a Master Of Science Degree in Chemistry, a Master Of Philosophy Degree in Chemistry, and a Doctoral Degree in Chemistry. Previous to becoming a Chemistry assistant professor at the targeted community college, instructor D taught two years of General Chemistry, Quantitative Analysis, and Analytic Chemistry at another college (Appendix F:67-68).

The problem addressed in this practicum was to determine the best method of closing the discrepancy gap between what entering students have previously learned in elementary, middle and high school about metric measurement and what was required for maximum comprehension in the college-level science and math curricula. The function of the targeted group of members in closing this discrepancy gap was initially to approve the different facets of this Metric System module and later to note any recommended revisions.

The objectives for this study were:

1. Within an indicated period of eighteen weeks, at least 75 percent of a group of instructors, which includes three science instructors and the chairperson of the Math, Science and Technology Division of the targeted community college, will approve the Metric System module. During the implementation period, frequent communication with the targeted group of instructors will allow brainstorming to occur. The instructors will have an opportunity to recommend support topics that should be included in the module. From previously instructing the Metric System, the professors will determine which objectives should be added or deleted from the module. As the module is being constructed, the constant verbal communication will allow the instructors to fully participate in any modifications that are deemed necessary. If one of the targeted instructors feels strongly about the deletion or addition of a particular instructional metric objective, the group will have an opportunity to examine the suggestion and either accept the recommendation and find alternatives or decide to reject the suggestion. The endorsement of the Metric System module by the indicated group of faculty will be accomplished by measurements made on three

post-surveys. The post-surveys will be administered by the author.

2. A minimum of 75 percent of the designated group of faculty will concur that the deficiency between what the students already know about the Metric System and what the students should be able to comprehend and apply in the Metric System has been addressed and completely covered in the Metric System module.

CHAPTER II

Research and Solution Strategy

In order to recommend a plan to better prepare the college level students for utilizing the Metric System, this writer examined various methods that have been utilized in the educational system. A common underlying philosophy was stated in each article and is directly quoted from Yvon and Marshall.

> We believe that the strategy of training metric leaders who possess a visceral knowledge of metrics, which enables them to think metrically and use the metric system as a survival skill, will be a major step in the metrication process and that the introduction of these leaders in the social network will act as a catalyst for metrication in the future. (Yvon, Butzow and Marshall, 1982:43)

Unfortunately many teachers on every grade level of our educational system do not desire to change from instructing the English System. McClendon (1989) offered three or four metric workshops weekly to teachers in the county. These teachers had a great deal of difficulty learning the Metric System because the group's knowledge of the decimal system was extremely weak.

The Florida third, fifth, eighth, and eleventh

grade state assessment tests' objectives include numerous metric skills for each grade level, but since the behavioral objectives deal with actual measurement performed by the student, testing the skills does not lend itself to written format exams given.

STATE OF FLORIDA METRIC

OBJECTIVES FOR THE 1989-90 SCHOOL YEAR

GRADE: 3

OBJECTIVE NUMBER: M-84

METRIC OBJECTIVE:

Given a unit of measure, determine the length of an object (centimeter).

GRADE: 5

OBJECTIVE NUMBER: M-88

METRIC OBJECTIVE:

Determine length, width or height by measuring object in terms of centimeters and meters.

GRADE: 8

OBJECTIVE NUMBER: M-89*

METRIC OBJECTIVE:

Determine capacity by measuring metric cups in terms of liters.

GRADE: 8

OBJECTIVE NUMBER: M-90*

METRIC OBJECTIVE:

Determine mass/weight by measuring to the nearest gram and kilogram.

GRADE: 8

OBJECTIVE NUMBER: M-91

METRIC OBJECTIVE:

Determine temperature using Celsius thermometer.

GRADE: 11

OBJECTIVE NUMBER: M-92*

METRIC OBJECTIVE:

Determine length or height by measuring to the nearest millimeter.

GRADE: 11

OBJECTIVE NUMBER: M-93*

METRIC OBJECTIVE:

Determine length, width or height of an object in millimeters and centimeters.

GRADE: 11

OBJECTIVE NUMBER: M-94*

METRIC OBJECTIVE:

Determine capacity by measuring quantities in millimeters.

GRADE: 11

OBJECTIVE NUMBER: M-95*

METRIC OBJECTIVE:

Estimate capacity in liters.

GRADE: 11

OBJECTIVE NUMBER: M-96*

METRIC OBJECTIVE:

Estimate mass/weight in grams and kilograms.

GRADE: 11

OBJECTIVE NUMBER: M-97

METRIC OBJECTIVE:

Identify freezing and boiling points of water, normal body temperature and compare air temperature in Celsius.

GRADE: 8

OBJECTIVE NUMBER: T-137

METRIC OBJECTIVE:

Solve linear measurement problems with centimeters and meters, using addition and subtraction with no conversions.

GRADE: 8

OBJECTIVE NUMBER: T-138

METRIC OBJECTIVE:

Solve capacity problems with liters using addition and subtraction with no conversions.

GRADE: 8

OBJECTIVE NUMBER: T-139

METRIC OBJECTIVE:

Solve mass/weight problems with grams and kilograms with no conversions.

GRADE: 11

OBJECTIVE NUMBER: T-141*

METRIC OBJECTIVE:

Solve problems involving the perimeter or area of a rectangular region using metrics.

GRADE: 11

OBJECTIVE NUMBER: T-142*

METRIC OBJECTIVE:

Solve problems related to length, width, or height using metric or customary units up to kilometers conversion within the system.

GRADE: 11

OBJECTIVE NUMBER: T-143*

METRIC OBJECTIVE:

Solve problems involving capacity using units given in a table (millimeters, liters) and conversion within the system.

GRADE: 11

OBJECTIVE NUMBER: T-144*

METRIC OBJECTIVE:

Solve problems involving mass/weight using units given in a table (milligrams, grams, kilograms and metric tons) and conversion within the system.

GRADE: 8

OBJECTIVE NUMBER: U-148

METRIC OBJECTIVE:

Using a table of metric measure, convert within the Metric System using the following units: millimeter, centimeter, meter, kilometer, milliliter, liter, milligram, gram and kilogram.

* Objective is one of actual measurement and is not presently being tested by the Florida State Assessment Tests.

The educational system is in a state of inertia, afraid to teach a new measurement system. Many teachers even assert that the United States will never

adopt the Metric System; therefore, why teach it? Gaughan and Wisner (1981:262) addressed this issue:

> But a great many teachers do not do much in their classroom with the metric system. We all know the reality of the situation: the changeover to the metric system may well be inevitable, but it is and will continue to be, very slow... However, during the interim years when conversion is underway, the challenges to educators is enormous and there are few easy answers. How do we as educators respond to and participate to and participate in this changeover?

Gaughan and Wisner (1981:262) stated as the basic philosophy that the field of mathematics should "...deal with the real world, and a curriculum that ignores this philosophy will simply reinforce the belief that mathematics is a dreary, boring, uninteresting and (aside from basic arithmetic) fundamentally useless subject." Metrics is used in sports, medicine, the sciences and industries all of which are significantly influenced by countries which have adopted the Metric System.

> The first and foremost reason (for slow metric conversion) is that the system seems so strange to so many, including our political leaders... There is in every society a resistance to change, and the United States is no exception. (Gaughan and Wisner, 1981:262)

The California school system has been phasing in the Metric System for a number of years, but the transition has been rescheduled several times over the

past few years. The over eagerness of the metric backers and metric textbooks overlooked the negative attitude of the American public to the Metric System. Illinois legislators decreed in 1975 that metric conversion would be complete by 1980, but like California did not meet deadline date. Resistance to change in Canada was also widespread before complete conversion. Even when the Canadian government required that all textbooks be totally metric, the Canadians resisted the conversion.

> A change to the metric system will not occur as rapidly as we might wish. With this awareness, we would do well to make sure that our curricula and textbooks include customary, household, and metric measurement, along with the instruction on converting from one system to another! (Gaughan and Wisner, 1981:262)

Members of the National Metric Council stated that the changeover to the Metric System is inevitable; the conversion will definitely occur in the next two or three decades. McGinty (1984) has noticed that many states and local school districts now require the teaching of metrics. A recent survey of California teachers indicated that school districts should require the instruction of the Metric System. Members of the National Council of Teachers strongly urged adoption and teaching of the Metric System at

all educational levels (McGinty, 1984:3). Hovey and Hovey (1983) cited the history and advantages of the Metric System as well as the methods applicable to instruction of the Metric System and stated, "As teachers we have a responsibility to adequately prepare our students for the metric world they will certainly face." (1983:112).

If the conversion to metric measure is to take place, the fourth corner of the puzzle (Figure 1:2) must be put into place to complete the perimeter. In order for a student to retain the familiarity and comprehension of the Metric System, the student needs to be instructed on the Metric System at each of the four educational levels. The collegiate system must identify a way to ascertain whether the college student has a sufficient knowledge of the Metric System. For those found to be deficient the college needs to provide the metric curriculum before actual practical application of the Metric System is instructed in the natural sciences, medicine and computer electronics.

Considering Americans' reluctance to progress towards conversion to the Metric System, attitudes of other countries that have converted, and positions taken by individual states planning to convert, the

writer concluded Florida along with the nation as a whole needed to put all of the pieces of the puzzle together. Three basic approaches which the target college might follow in completing the fourth piece of the puzzle are:

Option 1

Each student upon registering for a Biology or Anatomy and Physiology course take a Metric System Inventory test. If the student scores 80 percent or better on the inventory test, that student will be exempted from taking the Metric System module. If the student's score is less than 80 percent, the module will be required and be administered in the Math Lab. The module will include one videotape produced by this author, a computer disk entitled "Metric System Tutor", a workbook, and a competency test.

If the student does not score 80 percent or better on the Metric System Competency Test, the student will work with a Math Lab staff member to correct the erroneous responses and review the sections in the workbook that correlate to the skills tested. After strengthening necessary Metric System skills, the student will take the Supplemental Metric System Competency Test.

The videotapes will consist of the following nine topics: History of the Metric System, Present Adoption Status of the Metric System in the United States, Metric System to English System Conversion and vice versa, Metric Length Procedures, Metric Area Procedures, Metric Volume of a Solid Procedures, Metric Volume of a Liquid Procedures, Metric Mass Procedures, and Metric Temperature Procedures. The workbook will consist of worksheets designed by Brummel (1987) and Vos and Sandiford (1981) that instruct the student in the basic metric units of length, volume, mass and temperature, with additional worksheets provided by the author covering topics omitted by the above named authors. Permission has been granted to use the worksheets created by Brummel and Vos and Sandiford (Appendices G and H:70 and 72). The student will be required to pass a competency test with a minimum score of 80 percent or better on the Metric System Competency Test. The student should be required to rework the missed test questions with the aid of the workbook and a Math Lab staff member, and then take the Supplemental Metric System Competency Test.

Option 2

Upon entering the science course, each student takes a Metric System Inventory test in class. If the student's score is below 80 percent, viewing the videotapes in the Math Lab and successfully completing a set of worksheets will be required. The Metric Education Resources written by Vos and Sandiford (1981) include a series for post-secondary education. These workshop materials include a pre-test and a post-test, a list of films and filmstrips, and a list of videocassettes and audiocassettes.

Option 3

In order that every student be exposed to the Metric System and all possible applications, each science course will need to teach a unit on the Metric System. Alternative number two is a supplemental approach. The Basic Science Training Program, developed by Brummel (1987) includes "teacher in the classroom" instruction, worksheets and "hands-on" activities that enable the student to study and comprehend the Metric System (Brummel, 1987:1-23). Another complete system for teaching students the Metric System is supplied by Vos and Sandiford (1981). Pages 54 through 57 of this collection of instructional materials includes books, workbooks,

posters, manipulative aids and kits, films and filmstrips and videocassettes, slides and transparencies, audiocassettes and records. The American College Testing Program has developed metric instructional materials. Each student is supplied a workbooklet and a self-scored performance test (Kundel, 1979: 10-13). All of these metric programs demonstrate that the recommended approaches contain multi-sensory media, wherein the student has oral, visual and written instruction.

When a student uses a videocassette as the primary source of learning and experiences, absence of an instructor to answer questions and aid in placing the final piece of the metric puzzle, frustration and a continued reliance on the English System will result. To overcome this problem, the writer, a lab supervisor and teacher, will present the information on the videotape to attain the advantage of the student and teacher relationship in presenting a lesson.

This researcher felt alternative number one would be the most successful. Since 74 percent of the college instructors polled in the original needs assessment and 100 percent in the later needs assessment agreed the students should be instructed

before entry into science. The separate metric module accomplished this goal without being redundant for the students. The chosen option provides the student with a workbook and two different technological forms of media aid via the computer and a videotape recording. Knowing that the students will be either a visual learner, an auditory learner, a multi-sensory learner, or a kinesthetic learner, the various formats of educational materials should address the needs for all of the types of learners. The kinesthetic learner will benefit from the activity requiring actual metric measurement. If the student does not understand the meaning of particular metric terms in the workbook, or on the computer disk, or on the videotape, the Math Lab staff will provide learning alternatives for the student.

In response to the needs assessment given to the Science Department at the targeted college, the first option resolves the known areas which cause the student difficulty when applying the Metric System: History of the Metric System, Present Adoption Status of the Metric System in the United States, Metric System to English System Conversion, English System to Metric System Conversion, Metric Length Procedures, Metric Area Procedures, Metric Volume of a Solid

Procedures, Metric Volume of a Liquid Procedures, and Metric Temperature Procedures. This procedure of instruction will also allow the minority group of students who can demonstrate knowledge of the Metric System to move forward without further instruction. This alternative was chosen as the solution strategy for this study.

CHAPTER III

Method

During the first four weeks of designing the Metric System module, the author wrote the tutoring sections of the student's workbook, the three post-surveys to analyze a Metric System videotape, the "Metric System Tutor" computer disk, and the overall Metric System module. The fifth week was set aside for the author to share ideas with the targeted community college's audio-visual department for development of the Metric System posters to be utilized in the Metric System videotape. The audio-visual department then completed the graphics for the posters. In order to guarantee that the Metric System was taught in agreement with the methods used in the targeted community college's science department, each faculty member was given during the sixth and seventh weeks a personal copy of the tutoring sections of the student's workbook for review and to make recommendations (Appendix I:74-77). During the eighth and ninth weeks, the author made the suggested changes in the tutoring sections of the student's workbook. The exercises for the student to

complete before proceeding on to the next section and the instructor's manual will be written throughout weeks ten and eleven. The twelfth and thirteenth weeks was for the named faculty to evaluate the exercises and instructor's manual. The instructors were each given a copy of the exercises and a copy of the instructor's manual in which to make individual comments. The author made the recommended changes to the exercises and the instructor's manual during weeks fourteen and fifteen. Week sixteen was set aside for the writer to devise a script for the Metric System videotape and to be videotaped.

During weeks seventeen and eighteen the indicated faculty was given a chance to view the Metric System videotape, the "Metric System Tutor" computer disk, the final version of the student's workbook, and the final version of the instructor's manual. The group was given three post-surveys, one was for evaluating the Metric System videotape created by the author, another survey requested a review of the "Metric System Tutor" computer disk, and the last survey was for judging the entire Metric System module (Appendices J, K, and L:82, 84, and 86-87). Since the Metric System module will ultimately be taught by

the Math Lab staff, including the Practicum author, the following techniques will be stressed: identify those students whose metric comprehension needs to be strengthened; have the students learn to recognize various metric terms; administer exercises that will provoke discussions and questions to be asked by the students working in the Math Lab on the Metric System module; and, give the students an opportunity to contrast the Metric System and the English System by examples shown on the computer disk, the videotape, written and hands-on exercises in the workbook. Students will be allowed to estimate distances on a map, lengths in a classroom, liquid volume measurement of different common containers (to be done in the Math Lab), and area measurement of a window, a whiteboard, and a bulletin board. In some sections the students will be required to convert from the Metric System to the English System or vice versa, or within the Metric System. (During the initial stages of implementation, the entire targeted group of instructors recommended that a section on conversion within the Metric System be added.) Students will be asked to contrast the estimated measurement to the precise measurement.

The Math Lab will give the students encouragement when confusion over the Metric System procedures arise, invoke discussion as to why the United States is converting to the Metric System, and support the students' alternative methods for converting within the Metric System. The Math Lab will be a proper atmosphere for students to discuss each other's interpretations of rounding numbers and determining the number of significant digits in a measurement. Students, working in the Math Lab, will not be restricted to a time constraint of one class period. As with other courses that are supported in the Math Lab, the students will have the opportunity to teach and assist each other. When working with a Math Lab staff member, students will be able to spontaneously challenge the material in the Metric System module. As the students progress through the workbook, a synthesizing of the metric concepts will take place. After completion of the material, the students will validate comprehension of the Metric System skills through the Metric System Competency Test.

The students are encouraged to adapt the Metric System into everyday life by the "real life situation" assignments given in the workbook. Some of these

"real life situation" problems include: calculating the number of kilometers between two cities on a map; estimating the mass of a collection of paper clips and a square centimeter of paper; measuring the volume of a liquid in a soda bottle; and deducting the area for the top of a table. Throughout the Metric System module, the students are to recall and comprehend, apply, analyze, synthesize and evaluate the skills of the Metric System.

CHAPTER IV

Results

The two objectives stated in chapter one were evaluated by a panel of math and science experts. The results of the objectives were:

1. Successful evaluation measured by the three post-surveys, as mentioned in objective one, pages 17-18, administered to the three science instructors and the chairperson of the Math, Science and Technology division meant that at least three of the four instructors of the group would approve each of the following items: the Metric System videotape written by the author, the "Metric System Tutor" computer disk, and the completed Metric System module. The author distributed and evaluated results of the three post-surveys. The designated faculty were told of the results of the five initial needs assessments before design of the Metric System module was begun. Within the listing of the results, the instructors were informed of the nine topics requested by the instructors to be in the Metric System module. Since all preliminary work for this practicum was accomplished during the 1989-90 school year, the

writer and members of the target group evaluated all entering science students' prior knowledge of the Metric System skills. The participating students of the Metric System program were assigned during the 1990-91 school year following an administration of an author-developed test. Following the actual use of the "Mastering The Metric System" module, the conclusion was to be made as to whether the module is an optimum method to close the discrepancy gap between what entering students have learned about metric measurement and what is required for maximum comprehension in the college-level science and math curricula. Since state standards for grades three through twelve require 80 percent mastery before a student may progress to the next level, all of the five science classes averaged below 80 percent on the Metric System Inventory Test, given August, 1990 (Table 1:41).

2. On the "Mastering The Metric System" Videotape Post-Survey, 100 percent of the targeted group of instructors answered affirmatively that the problems displayed on the paper chart were clearly visable, the presenter's voice was audible, and the colored charts were appropriate for the discussion on the

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Table 1

Summary Of The August 1990
Metric System Inventory
Test Averages

Class #	Class Instructor	Number Of Students	Class Average
1	B	23	7.7
2	B	24	6.5
3	B	21	7.1
4	B	24	6.5
5	A	86	5.7

videotape. Two of the four instructors felt that the definitions and explanations given were easy to comprehend; the other two felt that some improvement could be made. All four of the targeted group felt that the length of the videotape was appropriate for the amount of material discussed on the videotape.

All of the instructors gave positive responses on the "Metric System Tutor" Computer Disk Post-Survey. Each of the instructors agreed with each of the following premises: the "Metric System Tutor" computer disk was user friendly; the graphics on the "Metric System Tutor" computer disk were legible and meaningful; the Metric System definitions were easy to comprehend; the Metric System definitions on the computer disk coincided with the workbook's Metric System definitions, and the examples on the computer disk were easy to follow. Instructor C commented, "I like this program. There is one typographical error in the first few screens... your're." Instructor B stated the following concerns, "I have trouble with computer learning as I find it too slow. Some, obviously, like this method of learning."

On the Metric System Module Post-Survey, 75 percent of the targeted group of instructors agreed

that the inventory test was a good evaluation for determining if the student had some comprehension of the Metric System, and that the competency test was a valid tool for testing comprehension of the Metric System. All four of the targeted group of instructors concurred that the Metric System definitions in the module were functional and easy to comprehend, the conversion instructions were clear, each set of problems related directly to the preceding explanation, and in the instructor's manual, the answers in the instructor's manual were complete and correct, the "Metric System Tutor" computer disk correlated with the "Mastering The Metric System" workbook, and the "Mastering The Metric System" videotape properly led into the Mastering The Metric System Workbook. Instructor A made the following remarks, "Nice job! These are fine." Instructor B gave the writer of the practicum a complimentary memorandum pertaining to the Metric System module (Appendix M:89). In the space left for additional comments or recommendations, Instructor D wrote, "I feel that through the different media you have done an excellent job in discussing the Metric System. It is obvious that you have spent a great deal of time on

this tedious subject. Thank you for allowing me to review the material. Again - Excellent!"

CHAPTER V

Recommendations

Since 100 percent of the designated group of faculty approved the final version of the Metric System module in the three post-surveys, the instructors have decided to adopt the "Mastering The Metric System" module in the target group's Biology Department. The successful completion of the Metric System module will be a requirement for every biology student at the targeted community college.

Instructor B felt that since there exist many different views of the ruling for significant digits and rounding within the college community, the concepts of significant digits and rounding should be deleted from the to be published version of the module. Instructor C made the following suggestions: when discussing a problem on the "Mastering The Metric System" videotape, create a short written version of each rule through the use of character generation; on the inventory test, replace the "bowling ball" with a more familiar item, and change the prefix "hecto-" to a more well-known prefix.

Due to the fact that the module was well received by the indicated group of instructors, the writer's mentor has suggested that the Metric System module be published. Accordingly, the author's desire is to publish the Metric System module so that the program can be used at other community colleges. When the writer contacted Brummel for permission to reproduce certain Metric System materials from the Basic Science Training Program, Brummel requested a copy of the final version of the author's Metric System module be forwarded. The writer desires to have the Metric System module become a part of the materials used at Brummel's college, Lake Michigan College, to instruct the Metric System. Before the writer submits the final copy of the Metric System module to prospective publishers, members of the target group of professors will be encouraged to suggest modifications, additions or revisions to the module.

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Appendices

Appendix A

Science Department Metric Needs Assessment

In order to determine the exact needs to be satisfied by this module, including factors of content and time necessary for student comprehension, this form was given to each member of the Science Department of the targeted community college.

Appendix A

Science Department Metric Needs Assessment

_____
PARTICIPANT

_____
TODAY'S DATE

Please circle the letter of the desired response. If more than one response is applicable, then circle as many responses as appropriate.

1) Which area(s) in the natural sciences do you instruct?

   a) Physics b) Biology c) Chemistry d) Zoology
   e) Anatomy and Physiology f) Earth Science
   g) Botany
   h) If the title of the course which is taught is missing from this list, write the title of the course below:

   _____

   _____

2) Is there a need for a prepared curriculum package for instructing the Metric System?

   a) Yes b) No

3) Within the indicated course, is the Metric System at least in part, presently taught to the students?

   a) Yes b) No

4) If the response to question three was yes, which category listed below best describes the number of class hours spent teaching the Metric System?

   a) Less than one hour b) 1 to 3 hours
   c) 4 to 6 hours d) 7 to 9 hours
   e) More than 9 hours

5) Is there a possibility of utilizing the following Metric System module next fall semester?

I. Give a Metric System Competency Test at the beginning of a science course.
II. If the student scored below 80% on the Metric competency test, require the student to complete a Metric System module in the Math Lab. The Metric System module would include a videotape, worksheets, and a competency-based post-test.

a) Yes b) No

6) Give an estimate of the time that should be devoted to each component by the student completing this activity:

a) Viewing videotapes _____ hours

b) Completing worksheets _____ hours

7) Check the topics desired to be covered in the Metric System module:

_____ History of the Metric System

_____ Present Adoption Status of the Metric System in the United States.

_____ Metric System to English System Conversion and vice versa.

_____ Metric Length Computation

_____ Metric Area Computation

_____ Metric Volume of a Solid Computation

_____ Metric Volume of a Liquid Computation

_____ Metric Mass Computation

Other recommended topics: _____

The author appreciates the time and effort that was taken to complete the Metric needs assessment.

Appendix B

Metric System Proficiency - Mathematics Department Needs Assessment

This needs assessment was given in order to determine what plans, if any, each mathematics instructor has to instruct the Metric System.

Appendix B

Metric System Proficiency - Mathematics Department Needs Assessment

MEMORANDUM TO: South Campus Math Instructors

SUBJECT: Metric Proficiency and Providing Instruction Where Deficiencies Exist

FROM: Marjorie Thrall
Math Department, South Campus

~~~~~~

At the present time, I am writing a change paper for my master's degree. My subject pertains to metric comprehension and supplying metric instruction where deficiencies occur. In order to verify that this situation may happen at various institutions and that a need for metric instruction exists, I would appreciate your completing the survey following:

1) Do you instruct the topic of the Metric System in any of your math courses?

_____

_____

2) If your response to number one was "yes," please state which of your own courses include the Metric System.

_____

_____

3) Do you feel that there is a need to instruct the Metric System to the college student before the student enters a science or computer electronics course?

_____

_____
~~~~~~

4) If you do feel that there is a need to instruct the Metric System before the student enters a science or computer electronics course, do you have any future plans to accommodate this need?

_____

_____

If your reply was "yes," what are your plans to take care of this need?

_____

_____

Comments:

_____

_____

_____

Thank you for your time and assistance. If I can ever be of service to you, please do not hesitate to contact me. I would appreciate a response on this survey.

_____ _____

Instructor's Name Department

Appendix C

Metric System Proficiency - Science Department Needs Assessment

This needs assessment was given in order to determine what plans, if any, each science instructor has to instruct the Metric System.

Appendix C

Metric System Proficiency - Science Department Needs Assessment

MEMORANDUM TO: South Campus Science Instructors

SUBJECT: Metric Proficiency and Providing Instruction Where Deficiencies Exist

FROM: Marjorie Thrall
Math Department, South Campus

~~~~~~

At the present time, I am writing a change paper for my master's degree. My subject pertains to metric comprehension and supplying metric instruction where deficiencies occur. In order to verify that this situation may happen at various institutions and that a need for metric instruction exists, I would appreciate your completing the following needs assessment:

1) Do you instruct the topic of the Metric System in any of your science courses?

_____

_____

2) If your response to number one was "yes," please state which of your own courses include the Metric System.

_____

_____

3) Do you feel that there is a need to instruct the Metric System to the college student before the student enters a science or computer electronics course?

_____

_____
~~~~~~

4) If you do feel that there is a need to instruct the Metric System before the student enters a science or computer electronics course, do you have any future plans to accommodate this need?

_____

_____

If your reply was "yes," what are your plans to take care of this need?

_____

_____

Comments:

_____

_____

_____

Thank you for your time and assistance. If I can ever be of service to you, please do not hesitate to contact me. I would appreciate a response on this needs assessment.

_____ _____

Instructor's Name Department

Appendix D

Determination of Standardized Examination Administration of Metric System Needs Assessment

In order to determine which standardized exams are presently administered at the targeted community college that test the student's Metric System skills, the following needs assessment was submitted to the Director of Student Services.

Appendix D

Determination of Standardized Examination Administration of Metric System Needs Assessment

MEMORANDUM TO: Mr. Wendell Rand
Director of Student Services

SUBJECT: Determination Of Standardized Examination Administration of Metric System Needs Assessment

FROM: Marjorie Thrall

I am presently doing a change paper for a course that I am taking in the GEM Program at Nova University. My topic is to find ways to introduce teaching the Metric System to all of our degree seeking students. I have been informed, by many of our science instructors, that most of our students upon entering their first college level science course do not know how to use the Metric System.

To help design a possible program, I am seeking your response to the following questions:

1) Does the MAPS exam that we give to our students contain any questions on the Metric System?

_____

_____

2) Does the ACT exam that we previously gave our students, contain any questions on the Metric System?

_____

_____

3) Does the SAT exam that some of our students take contain have any questions covering the Metric System?

_____

4) What percentage of Manatee Community College students each year take the Topics in Math course?

_____

_____

Thank you for your assistance.

Appendix E

Metric Needs Assessment to the Math, Science, and Technology Divisions of Neighboring Community Colleges

In order to research the various methods of instructing the Metric System at neighboring community colleges, the following needs assessment was submitted to the Division chairpersons of Math, Science, and Technology at five community colleges.

APPENDIX E

Metric Needs Assessment to the Math, Science, And Technology Divisions of Neighboring Community Colleges

Marjorie A. Thrall
Math Department
Manatee Community College
8000 South Tamiami Trail
Venice, Florida 34293

Dear _____,

At the present time I am writing a change paper for my Master's Degree . My subject pertains to metric proficiency and providing metric instruction where deficiencies exist, particularly as it relates to college science and computer electronics courses. In order to verify that this problem occurs in other institutions and that a need for metric instruction exists, I am asking you for your response to the following:

1) Are the students first instructed the topic of the Metric System in your science courses or is it also taught in your math courses?

_____

_____

2) Do your science instructors feel that more of an emphasis needs to be placed on the teaching of the Metric System before the student enters a science course?

_____

_____

3) If you do feel that there is a need to instruct the Metric System before the student enters a science or computer electronics course, do you have any present plans to accommodate this need?

_____

_____

If your reply was "yes," what are your plans to take care of this need?

_____

_____

Comments:

_____

_____

_____

Thank you for your time and assistance. If I can ever be of assistance to you, please do not hesitate to contact me.

Appendix F

Summary Of Target Group Of Instructors' Demographic Data

The Target Group Of Instructors' Demographic Data includes statistics on each of the following categories: sex, age, marital status, number of dependents, educational background, years of experience, and areas of expertise.

Appendix F

Summary Of Target Group Of Instructors' Demographic Data

	Number	Percent
Sex		
Female	1	25
Male	3	75
Age		
30 to 35 years	1	25
36 to 41 years	1	25
42 to 47 years	2	50
48 years and up	0	0
Marital Status		
Unmarried	0	0
Married	4	100
Number Of Dependents		
Zero	1	25
One	0	0
Two	2	50
Three	0	0
Four or more	1	25
Educational Background		
Bachelor's Degree	0	0
Master's Degree	2	50
Doctoral Degree	2	50
Years Of Experience		
1 to 6 years	1	25
7 to 12 years	1	25
13 to 14 years	1	25
15 years and up	1	25
Areas of Expertise		
Biology and Plant Physiology	1	25

	Number	Percent
Areas Of Expertise		
Chemistry and Physical Science	1	25
Mathematics and Computer Science	1	25
Medicine, Surgery, Avian Ecology, and Biology	1	25

Appendix G

Written Approval to Use the Worksheets Created by Brummel

A letter was received from Brummel giving the author permission to use the worksheets written by Brummel in the creation of the Metric System module.

Lake Michigan College

2755 East Napier Avenue
Benton Harbor, MI 49022-1899
(616) 927-3571

February 8,1990

Marjorie A. Thrall
128 Da Vinci Drive
Nokomis, Florida 34275

Dear Ms. Thrall:

As per our phone conversation of 7 February, 1990, you have my permission to reproduce materials from the module on the Metric System which is a part of the Basic Science Training Program which I have designed. If these materials are used acknowledgment will be appreciated.

If there is any other assistance that I might provide in the development of your practicum, please do not hesitate to contact me. Any data on its use that you might accumulate will be appreciated at the appropriate time.

Sincerely,

Clete Brummel

Clete Brummel
Professor of Biology

We'll Get You There

Appendix H

Written Approval to Use the Worksheets Created by Vos and Sandiford

A response was received from Vos and Sandiford giving the author permission to use the worksheets written by Vos and Sandiford in the creation of the Metric System module.

Marjorie A. Thrall
128 Da Vinci Drive
Nokomis, Florida 34275

72

Mr. Robert Vos
Ms. Janice Sandiford
Florida International University
Miami, Florida

Dear Mr. Vos and Ms. Sandiford,

Upon doing the research for a practicum for Nova University, I discovered the Metric Education Resources for Health Educators, at a workshop for Health Educators, that you developed. As my practicum is trying to implement a Metric unit into the community college curriculum, your worksheets and materials would be a great asset to the project. I have recently surveyed three hundred seventy-eight science students on our south campus at Manatee Community College. (This is our entire student population who are presently taking a science course). The average grade was 6.9 questions correct out out fifteen questions. I would like permission from you to reproduce some of your metric materials for the implementation part of the practicum. I would also like to purchase the transparencies. My work telephone number is 813-493-3504, extension 2623. If you have any questions or concerns, please do no hesitate to contact me.
Thank you very much.

Sincerely,
Marjorie A. Thrall
Marjorie A. Thrall

The OH transparencies are not available. You have permission to use the materials as you specify in this letter.
Good Luck!

Appendix I

Summary Of Recommended Changes Given By The Target Group Of Instructors

The list of recommended changes were compiled during the sixth and seventh weeks of designing the Metric System module. Each faculty member was given a personal copy of the tutoring sections of the student's workbook for review and were requested to make recommendations.

Appendix I

Summary of Recommended Changes Given By The Target Group of Instructors

Instructor A:

1. Within the instructional procedures the title of the pre-test, the "Metric System Inventory Test," should be mentioned each time a reference is made about the students who score below 80 percent and who are to complete the Metric System module.
2. Eliminate the word "please" in the instructions for the Metric System Inventory Test. When telling the student to bubble in the letter to the correct response on the answer sheet, do not mention the word "scantron."
3. Delete the capacity section in the student's workbook. Since the student workbook also includes a section on volume, delete the section discussing capacity. There does not exist a clear difference between the words "volume" and "capacity." Having the two sections within the same workbook is too confusing for the student.
4. Place the word "procedures" after the title of each of the instruction sections.

5. Eliminate all commas in numbers with three or more digits to the left of the decimal point. Students will have difficulty distinguishing between the periods and the commas.
6. The section instructing the "Conversion Within The Metric System" needs additional exercises.
7. Use matching sets of initial instructions for the "Metric System To English System Conversion" section and the English System to Metric System Conversion section.
8. Make sure that the problem is mentioned at the beginning of each example.
9. State the final answer on the right side of the equal sign on the last step of each example.
10. Eliminate the words "redi-mix" within the following phrase: "when a company orders redi-mix..." The reference to "redi-mix" sounds like a brand name has been used.
11. Convert the order of the sections within the workbook. (The final order of the sections is the order that instructor A suggested.)

12. Discard the phrase "...minimum amount of confusion..." in the sentence "This Metric System module is designed for the student to learn the Metric System with a minimum amount of confusion." This remark assumes confusion.
13. Reword the sentence which tells the student not leave a particular section of the module until all of the incorrect answers have been perfected. The assignment should be changed to "...problems have been answered correctly."
14. Disuse the Metric System Math Paks booklets. The student would do better working with the Math Lab staff and take a Supplemental Metric System Competency Test.
15. Change the Metric System prefixes so that the prefixes are not in alphabetical order, but in the order of smallest to largest.
16. The rules should have the following format: "Rule: ..." at the beginning of each rule and have the letters in bold print.
17. When discussing the topic of rounding, do not use the " ≈ " symbol. Use the words "rounded becomes."

18. Do not tell the student to do the exercises on a separate sheet of paper. Have the student write in the workbook.
19. Number each section and the exercises as a separate item from the part stating the rules. Each set of exercises should utilize the same section number as the rules and have the word "exercises" within the title.
20. Use the " • " symbol and not the "x" symbol for multiplication.

Instructor B:

1. Recommend the writer place in the student's workbook a section on the topic of "rounding" and a section on "significant digits."
2. Since the concept of weight is not taught in the biology courses, the discussion of weight is advised not to be placed in the student's workbook. Weight uses the term "newtons." The notion of weight is taught within the physics courses. Due to the fact that none of the targeted group of instructors teach physics, the concept of weight should not be included in the student workbook.

Instructor C:

1. Suggest that there should be a consistency of the use of capital letters within the Metric system Prefix exercises.
2. In instructor C's classes the addition rules for rounding are used for all of the four operations: multiplication, division, addition, and subtraction.
3. The usage of the chart for instructing the conversion within the Metric System is a nice idea.
4. Research the deletion of the small, raised circle for Kelvin.
5. Redesign the centimeter and millimeter grid. The present format is too confusing for the student. (The final version of the centimeter and millimeter grid was approved by instructor C.)

Instructor D:

1. Double check to see if the name "IIgs" should be in a mixture of upper and lower case or all upper case. (The writer discovered that the letters should be all in upper case.)

2. Investigate whether the place value "ten's" should have the apostrophe before or after the letter s.
3. The period at the end of the number "25.764." is not required.
4. In the example: 820.478 six significant digits

   X 790

   there should be more spaces between the number "820.478" and the words "six significant digits."
5. Under the Metric System prefix definitions, there should exist a column for "size." (This suggestion was not followed. The other instructors did not concur with this recommendation.)
6. Define the concept "volume" as the "amount of space taken up by an object." Draw a picture of a rectangular solid within the section on volume.
7. Write the variables L, W, H, and V in a formula format.
8. In the conversion of 1 dm = _____ cm, include the following step:

$$1\ L = 1\ dm^3 = (1\ dm)^3$$

9. Instead of saying that mass is the measurement of matter, state that mass is the quantity of matter.
10. Delete the following quotation:
    "All molecular motion does not necessarily cease at absolute zero, but none is available for transfer to other systems, and it is therefore correct to say that the energy at absolute zero is minimal."
    In instructor D's opinion, the above statement is not true.
11. Mention that the slug was historically used as the English unit for mass but, at the present time, the pound is primarily utilized.
12. "Very good work! Thanks for letting me go through it!"

Appendix J

"Mastering The Metric System"
Videotape Post-Survey

In order to ascertain the opinions of the "Mastering The Metric System" videotape, the following form was completed by each of the targeted instructors.

Appendix J

"Mastering The Metric System"
Videotape Post-Survey

Instructor's Name _____ Today's Date _____

Questions	Responses		
	Yes	No	Needs Improvement
1. Are the problems displayed on the paper chart clearly visible?			
2. Is the presenter's voice audible?			
3. Are the colored charts appropriate for the discussion on the videotape?			
4. Are the definitions and explanations given easy to comprehend?			
5. Is the length of the videotape appropriate for the amount of material discussed on the videotape?			

PLEASE USE THE SPACE BELOW FOR ADDITIONAL COMMENTS OR RECOMMENDATIONS:

_____

_____

_____

Appendix K

"Metric System Tutor" Computer
Disk Post-Survey

In order to ascertain the opinions of the "Metric System Tutor" computer disk, the following form was completed by each of the targeted instructors.

Appendix K

"Metric System Tutor" Computer
Disk Post-Survey

Instructor's Name _____ Today's Date _____

Questions	Responses		
	Yes	No	Needs Improvement
1. Is the "Metric System Tutor" computer disk user friendly?			
2. Are the graphics on the "Metric System Tutor" computer disk legible and meaningful?			
3. Are the Metric System definitions easy to comprehend?			
4. Do the Metric System definitions on the computer disk coincide with the workbook's Metric System definitions?			
5. Are the examples on on the computer disk easy to follow?			

PLEASE USE THE SPACE BELOW FOR ADDITIONAL COMMENTS OR RECOMMENDATIONS:

_____

_____

_____

Appendix L

Metric System Module
Post-Survey

In order to ascertain the opinions of the Metric System module, the following form was completed by each of the targeted instructors.

Appendix L

Metric System Module Post-Survey

Instructor's Name _____ Today's Date _____

Questions	Responses		
	Yes	No	Needs Improvement
1. Is the inventory test a good evaluation instrument for determining if the student has some comprehension of the Metric System?			
2. Are the Metric System definitions functional?			
3. Are the Metric System definitions easy to comprehend?			
4. Are the conversion instructions clear and complete?			
5. Does each set of problems relate directly to the preceding explanation?			
6. In the instructor's manual, are the answers to the questions complete and correct?			
7. Is the competency test a valid tool for testing comprehension of the Metric System?			

8. Does the "Metric System Tutor" computer disk correlate with the Mastering The Metric System workbook?			
9. Does the "Mastering The Metric System" videotape properly lead into the Mastering The Metric System workbook?			

PLEASE USE THE SPACE BELOW FOR ADDITIONAL COMMENTS OR RECOMMENDATIONS:

Appendix M

Commendation From Instructor B Of The Target Group

After the implementation of the creation of the Metric System module, instructor B of the target group of instructors wrote this memorandum to the practicum writer.

Manatee Community College

Appendix M

Commendation From Instructor B
Of The Target Group

6 December 1990

To: Marjorie A. Thrall

From: Wade L. Collier awc

Subject: Metric System Competency

On behalf of my colleagues in the Science Department, I want to commend you for the excellent work you did in helping our students master the metric system. We especially appreciated how you carefully worked with each of us before writing the metric system student workbook. Many of our science students who worked with you in the Math Lab reported how helpful they found the workbook and the acompanying video which you also prepared.

It is good that the Math Department and the Science Department can work together for the mutual benefit of our South Campus students.

cc: Mr. Campbell
Ms. Panik

BEST COPY AVAILABLE

Attachment A

"Mastering Of The Metric System"
Videotape Script

"Mastering The Metric System"
Videotape Script

In order to "master" a subject, a student must fully understand the concepts contained within the material as well as learn how to properly use them. On this videotape the viewer will learn about the past, present, and hopeful future of the Metric System. After the discussion, the following topics will be examined: Rules For Rounding Off Numbers, Rules For Computing The Number Of Significant Digits, Metric Vocabulary and Prefix Definitions, Metrication Rules, Conversion Within The Metric System, Metric System To English System Conversion, English System To Metric System Conversion, Metric Length Procedures, Metric Volume Procedures, Metric Mass Procedures, and Metric Temperature Procedures.

The Metric System became a means of legal measure in the United States by an act of Congress on July 28, 1866, and is currently found as law under United States Code, Title 15, Chapter 6, sections 204 and 205. The United States was one of only seventeen countries present at the signing of the Treaty of the Meter in 1875, which initiated the International Bureau of Weights and Measures and resulted in the new

distribution of platinum-iridium standards for the meter and the kilogram. As of 1893 Mendenhall, Superintendent of the United States Coast and Geodetic Survey and the Office of Weights and Measures transferred the American primary standards of length and mass to the meter and the gram.

The United States and Burma are the only countries still using the British system of measurement i.e., inches, feet, miles, pounds, gallons, et cetera. Two laws have been enacted within the last 15 years to promote the use of metric measure. The Education Amendments of 1974 were passed to encourage the study of the Metric System in the classroom. The Metric Conversion Act of 1975 was passed with the intent of having the official policy of the United States promote more planned use of the Metric System. When the Metric Conversion Act became law, a seventeen member board comprised of representatives from industry, small business, the labor force and other sectors of the economy was formed to encourage and facilitate voluntary conversion to the Metric System and to coordinate the education of different sectors of the American community. Educators have promised to help the

country convert by teaching the Metric System to American students. The United States Congress has mandated the conversion to the Metric System by October 1, 1992.

Before beginning our discussion of the Metric System a brief review of the Rules for Rounding Off Numbers and Rules for Significant Digits will be presented. Listed on the chart to my right are the names of the four places to the left and to the right of the decimal point.

thousands	hundreds	tens	ones	tenths	hundredths	thousandths	ten-thousandths

Rule: If the digit to the right of the place being rounded off is more than five add one to the digit being rounded, and have all subsequent digits become zeros.

Here is an example relating to the previously mentioned rule:

Round off 376 to the hundreds' place.

Since the digit to the right of the three is more than five, a one is added to the three and the digits in the tens' place and the ones' place become zeros.

Therefore, 376 rounded to the hundreds' place becomes 400.

Rule: If the digit to the right of the place being rounded off is less than five, the digit being considered for rounding does not change and all subsequent digits become zeros.

Here is an example of the rule:
Round off 721 to the hundreds' place.

Since the digit to the right of the seven is less than five, the seven remains the digit in hundreds' place, and the subsequent digits become zeros.

Therefore, 721 rounded to the hundreds' place becomes 700.

Rule: If the digit to the right of the digit being rounded off is five:

a) And there are only zeros after the five, do one of the following procedures:

i) If the digit in front of the five is an odd number, "round" the digit up by adding

one to the digit and have all subsequent digits become zeros.

Here is an example of the rule:
Round off 3500 to the thousands' place.

Since a three is in the place to be rounded and the three is an odd number, a one is added to the three. The five following the three becomes a zero.
Therefore, 3500 <u>rounded</u> to the thousands' place becomes 4000.

ii) If the digit in front of the five is even number, no change is made to that number and have all subsequent digits become zeros.

Here is an example of the rule:
Round off 2500 to the thousands' place.
Since a two is in the place to be rounded and the two is an even number, no change is made to the two. The five following the two becomes a zero.

Therefore, 2500 <u>rounded</u> to the thousands' place becomes 2000.

Rule: If the place to be rounded off is to the right of the decimal point, the final form of the number will not be written past the place to be rounded off.

Here is an example of the rule:
Round off 3.682 to the tenths' place.

The digit in the tenths' place is a six and the digit to the right is an eight. Since the digit to the right was greater than five, a one is added to the six and all subsequent digits will be dropped.

Therefore, 3.682 rounded to the tenths' place becomes 3.7.

Rule: When adding or subtracting a group of numbers, the answer should contain the smallest amount of decimal places used by any of the numbers in the problem.

Here is an example of the rule:
State the number of digits to the right of the decimal point that should be left in the final version for the following addition problem. Give the answer with the correct number of significant digits.

4321.6793

234.12

\+ 7.352

4321.6793 has four decimal places. 234.12 has two decimal places. 7.352 has three decimal places. Since the smallest number of decimal places used to the right of the decimal point was two, the sum should be rounded off to only two decimal places to the right of the decimal point (hundredths' place). Therefore, the answer before rounding was 4563.1513 and after taking into consideration the number of significant digits, the final answer becomes 4563.15.

Rule: When a multiplication or division problem is given, one should count the number of significant digits in each number. If the number does not contain digits to the right of the decimal point, the zeros used are only place holders and can not be considered as significant digits.

If the number is greater than or equal to one, then all digits to the left and to the right of the decimal point are considered significant. Reading left to right, if there is only a zero to the left of the decimal point, the counting of the significant digits begins with the first non-zero digit. The final version of the answer should utilize the minimum number of significant digits used by any of the numbers in the problem.

Here is an example of the rule:

456.789

x 34.22

456.789 has six significant digits. 34.22 has four significant digits. Therefore, the answer before rounding is 15631.31958 and after taking into consideration the number of significant digits, the final answer becomes 15630.

We now begin our discussion of the Metric System by reviewing several important definitions. The meter is the basic metric unit for measuring length; approximately one ten-millionth of the distance from the equator to the North pole, measured on the meridian. The liter is the most commonly used metric unit for measuring the volume of a liquid.

A liter of water at standard temperature and pressure has a mass of one kilogram. The gram is the basic unit for measuring the mass of an object. Mass refers to the amount of matter in an object. Unlike weight, the mass of an object remains constant, no matter where the object is located. The tonne, spelled t, o, n, n, e or metric ton is the basic unit of metric measure for objects of very large mass and is equal to 1000 kilograms. The Celsius Scale is a measurement of

temperature that was originally referred to as the Centigrade Scale. A capital C preceded by the degree symbol designates the temperature in degrees Celsius. At 0 °C water freezes and at 100 °C water boils. The Kelvin Scale for designating temperature is primarily used for engineering and physics. The freezing point of water on the Kelvin Scale is 273.15 K. Water boils at 373.15 K. The Kelvin Scale is a measurement of temperature equal to the Celsius Scale plus 273.15. The notation for the Kelvin Scale does not include the small degrees symbol.

As you can note on the salmon-colored board to my left, there exists a standard set of prefixes for the Metric System. These prefixes are used with the meter, liter, and gram. "Mega-" is symbolized by a capital M and means one million times of the metric unit. "Kilo-" is symbolized by a lower case k and means one thousand times of the metric unit. "Hecto-" is symbolized by a lower case h and means one hundred times the basic unit. "Deka-" is symbolized by the letters da and means ten times the metric unit. "Deci-" is symbolized by a lower case d and means one tenth of a metric unit. "Centi-" is symbolized by a lower case c and means one hundredth of a metric unit. "Milli-" is symbolized by a lower case m and means

one-thousandth of a metric unit. "Micro-" is symbolized by the Greek letter, u, and means one millionth of a metric unit. "Pico-" is symbolized by a lower case p and means one trillionth of a metric unit.

An example of a utilizing one of the prefixes would be the term "centimeter," which means one hundredth of a meter.

Rule: Unless the metric symbol is at the end of a sentence, the metric symbol should not be followed by a period.

Here is an example of the rule:

mm, not mm.

Rule: When the number of metric units is less than one, a zero is placed in front of the decimal point.

Here is an example of the rule:

0.16 cg, not .16 cg

Rule: Exponents are used when describing square and cubic units.

Here are two examples of the rule:

25 mm^2, not 25 square millimeters

72 mm^3, not 72 cubic millimeters

Rule: The preferred use of units when numerals are given is to write the metric symbol in place of the metric name.

Here is an example of the rule:

12 dL, not 12 deciliters

Rule: The metric symbols are written in singular form.

Here is an example of the rule:

24 mg, not 24 mgs

Rule: A space is left between the numeral and the metric symbol.

Here is an example of the rule:

5 mL, not 5mL

Rule: Decimal fractions are utilized in place of common fractions.

Here is an example of the rule:

3.7 km, not 3 7/10 km

Rule: Except for Celsius, Kelvin, the prefix "Mega-", the prefix "Giga-", and the liter, all the letters for the metric names are written in lower case. The ruling excludes the case where the metric name is at the beginning of a sentence.

Here is an example of the rule:

3.2 cg, not 3.2 CG

Rule: Compound symbols are separated by a slash (/) instead of the word "per."

Here is an example of the rule:

m/s, not meters per second

As you now see on the yellow board, when converting from one type of metric unit to another type of metric unit, the decimal point will be moved a certain number of decimal places to the left or right. Place a decimal point in the right hand side of the box with the column heading of the original metric unit.

If the initial value was greater than or equal to one, put the ones' place digit in the same box as the decimal point, with the decimal point to the right of the ones' place digit.

Rule: Write any digits which were to the right of the decimal point in the boxes to the right of the decimal point. Be sure to write only one digit per box. If there were more digits to the left of the ones' place digit, place those digits to the left of the box containing the decimal point.

Note the examples shown on the yellow board to my far right:

The first problem was: 46.3 g = _____ cg.

Note that in the example the original decimal point was initially placed in the grams' column. The second step was to move the decimal point to the "new" metric unit, centigrams. When the decimal point is being moved to the new column, every box must contain a

digit. If the box is empty the digit zero is to be put in as a place holder. The original number has become 46.30 in order for there to be a digit in every box needed for the conversion. Recall that the zero in the number 46.30 is strictly being used as a place holder and does not change the actual value of the number. Hence, 46.3 g = 4630 cg.

Utilizing the fact that 100 cg = 1 g, a fraction method for the same problem would be the following:

Since $\frac{100\ cg}{1\ g} = 1$,

multiply $\frac{46.3\ g}{1} \cdot \frac{100\ cg}{1\ g}$.

The 46.3 g quantity was placed over one in order that two fractions could be multiplied. Since 46.3 g can be divided by 1 g, the "1 g" was written as the second fraction's denominator. When 46.3 g is divided by 1 g, the "46.3 g" becomes "46.3" and the "1 g" becomes "1." The final step is to multiply 46.3 times 100 cg. The product of the denominators is one and the product of the numerators is 4630 cg. Recall that any number divided by one is equal to the original number. Therefore, the final answer is 4630 cg.

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